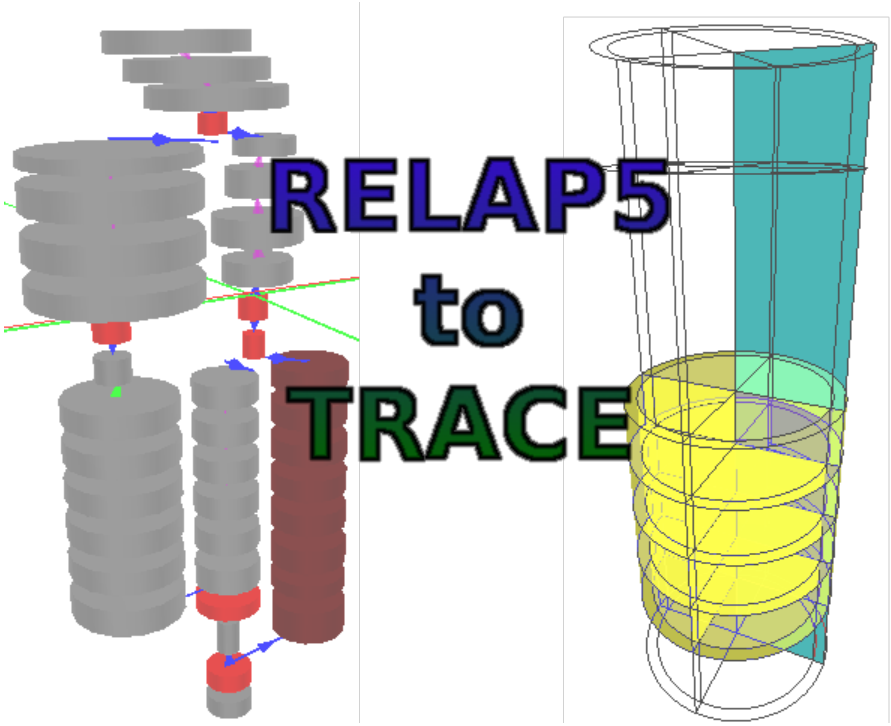
R52TRACE Plug-in Users Manual

Symbolic Nuclear Analysis Package (SNAP)



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R52TRACE Plug-in Users Manual

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Chapter 1. Introduction

The Symbolic Nuclear Analysis Package (SNAP) consists of a suite of integrated applications designed to simplify the process of performing thermal-hydraulic analysis. SNAP provides a highly flexible framework for creating and editing input for engineering analysis codes as well as extensive functionality for submitting, monitoring and interacting with the analysis codes. The modular plug-in design of the software allows functionality to be tailored to the specific requirements of each analysis code.

The TRAC/RELAP Advanced Computational Engine (TRACE) is a best-estimate reactor systems code developed by the U.S. Nuclear Regulatory Commission (NRC) as the product of an effort to combine TRAC-P, TRAC-B, RELAP and RAMONA. TRACE is designed for analysing neutronic-thermal-hydraulic behavior in light water reactors.

RELAP5was developed for best-estimate transient simulation of light-water reactor coolant systems, and models the reactor coolant system coupled with the core for loss-of-coolant accidents. Its generic modeling approach permits simulating a variety of hydraulic systems.

RELAP5 and TRACE are currently supported by SNAP. The RELAP5 to TRACE conversion plug-in (R52TRACE) is designed to convert RELAP5 models complete with control systems, kinetics, and heat structures into functionally equivalent TRACE models. After the conversion process is complete a report is generated that details the conversion results. The report can be exported to an HTML file.

1.1. Installation Instructions

SNAP plug-ins are loaded when the ModelEditor is opened or when the Calculation Server is started. These plug-ins are loaded from the **plugins** directory located in SNAP's installation directory. The SNAP installation directory defaults to C:\Program Files\snap\ under Microsoft Windows and /usr/local/snap/ under Apple OS X, Linux and Unix systems. To install the R52TRACE plug-in, simply copy the file r52trace_plugin.jar from the distribution into the **plugins** directory of the SNAP installation. The R52TRACE plugin will then be available the next time the ModelEditor is started. A list of the installed plug-ins along with their version information can be displayed by selecting the Plug-ins button located on the ModelEditor's About dialog.

Chapter 2. User Interface

The R52TRACE conversion plug-in is available on the Tools menu when a RELAP5 model is selected. The menu item, shown in Figure 2.1, “Conversion Menu Item”, opens the primary conversion dialog which controls the conversion processed. If the model has been previously converted to TRACE, the dialog will open on the last panel displayed during the most recent conversion process.

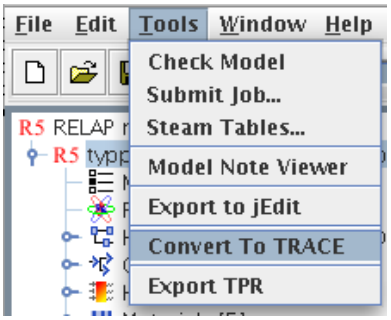

Figure 2.1. Conversion Menu Item

2.1. Component Selection

The category selection panel displays the list of categories of components in the selected RELAP5 model that can be converted to TRACE. Figure 2.2, “Category Selection Panel” displays the selection panel in the conversion dialog. When a category is selected, the panel provides s selection button which opens a component selection dialog also displayed in the figure which allows selecting individual components from a category for conversion. All of the components within a selected category are included by default when the category is initially selected. The component selection dialog allows the user to remove individual components from the selection.

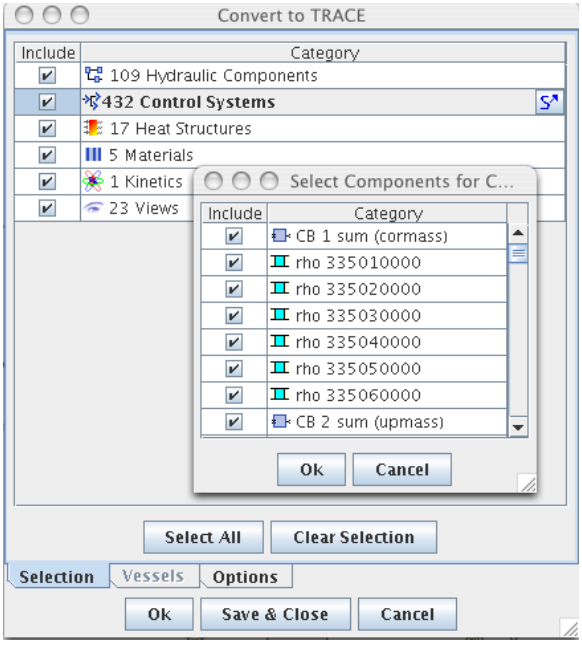

Figure 2.2. Category Selection Panel

2.2. Conversion Options

Certain component converters allow the user to specify values during the conversion process. For example, the user defined material tables in RELAP5 define volume heat capacity as either a constant, or a function of temperature. TRACE user defined materials however require specific heat. To convert the two values, a density is required. To simplify the conversion a constant density is defined, along with a constant emissivity. Both of these values may be specified for each of the materials converted, though default values are provided. Figure 2.3, “Converter Options Panel” below displays the options panel, with a material converter selected.

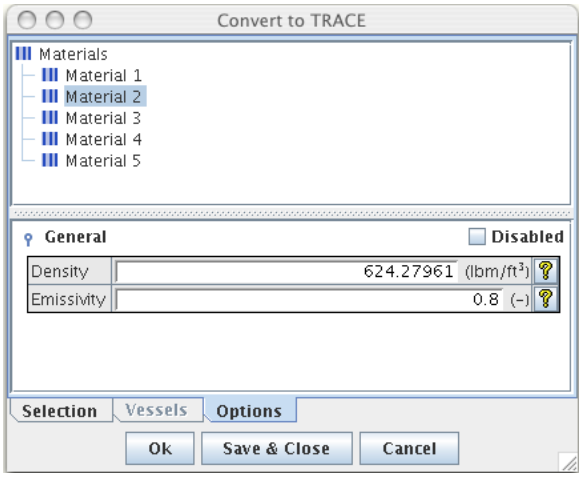

Figure 2.3. Converter Options Panel

2.3. Conversion Report

After completing the conversion, the results will be presented in a report dialog, as shown in Figure 2.4, “Report Dialog”. The report dialog details each RELAP56 component that has been converted, and lists the corresponding TRACE components. The info button in the results column opens a small dialog which displays concerning the conversion process for that component. This includes the numbers and types of components created, and key component properties before and after the conversion. For example hydraulic components display the total volume and elevation change before and after the conversion, and heat structures display their total inside and outside surface areas.

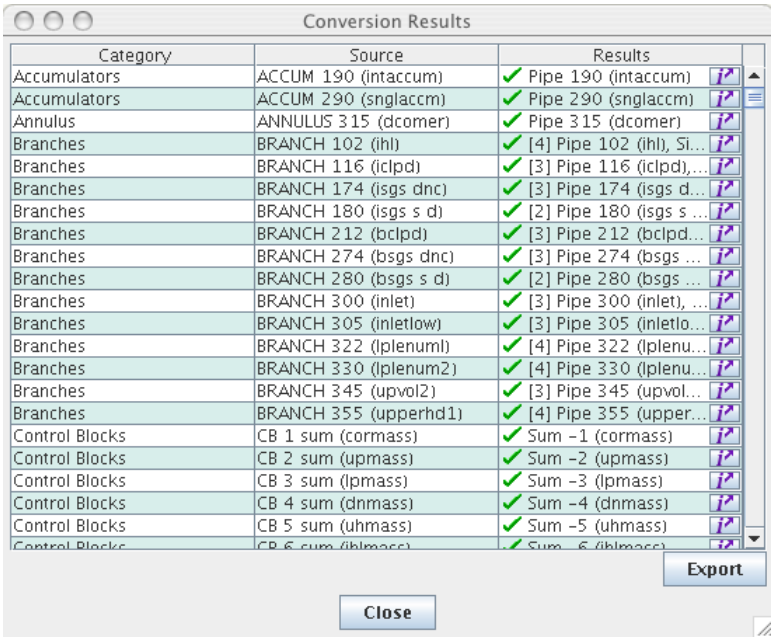

Figure 2.4. Report Dialog

Chapter 3. Conversion Details

3.1. Hydraulic Components

All hydraulic components defined in a RELAP5 model can be converted into corresponding TRACE hydraulic components. TRACE V 2.0 provided support for elevation changes applying at the edges of hydraulic cells through the namelist variable ILEV = 3. The hydraulic state properties from RELAP are converted to the TRACE state values by using the steam tables. This causes problems when the desired state is outside the blank region.

3.2. Heat Components

The heat structure components are converted into the corresponding TRACE heat structures. The primary point of interest is that source data for heat structures is converted to Power components in TRACE. The resulting power component provides a power in the same way as the original heat source. Only heat structures with uniform source data will spawn a power component. The heat structure source multiplier (ISM) value is preserved as the axial power profile for the heat structure, and if reflood is turned on, the power profile duplicate the first and last rows.

3.3. Power Components

The Point Kinetics model inside RELAP5 is converted into a Power component inside the TRACE model. Each heat structure in the RELAP5 model that specified the Reactor Kinetics for a source location is connected to the Power component. The resulting power component will incorporate general tables from the RELAP5 model directly into the power tables in TRACE. The feedback tables in RELAP5 are dependent on moderator density, and as such cannot be converted directly to TRACE. Trace uses a combination of moderator temperature, and void fraction for determining reactor feedback.

3.4. Control Components

The control systems inside a RELAP model are converted into the equivalent values inside TRACE. There are several RELAP5 control components that have no direct correlation in TRACE. The RELAP5 logical trips are converted to small control networks that produce a TRACE trip with a logical control component as an input value. The following RELAP5 Control components cannot be converted to trace, as they have no corresponding system.

1. Shaft Controller
2. Pump Conmponent Controller
3. Steam Flow Controller
4. Feedwater Flow Controller
5. Digital Timer
6. Inverse Kinetics Component

Chapter 4. Open Issues

Dispite the similarities between RELAP5 and TRACE, the inherent differences between their input specifications may require modification by the user either before or after model conversion. Most simple models convert automatically with no additional action required, however more complex models will be likely required additional model editing. The primary areas of concern include cell elevation changes, treatment of multiple inlet and outlet connections, unsupported RELAP5 signal variables, radiation enclosure beam lengths, heat structure general tables, control system engineering units, and unsupported components.

4.1. Multiple Inlet and Outlet Connections

RELAP5 allows any number of hydraulic connections to any face of a volume. This includes internal edges. This behavior can be mimiced with cross flow connections in TRACE, however when the orientation of the source and target cells differ, the elevation change across the crossflow connection may not be preserved. For example consider the case of a horizontal pipe connected to the inlet of a vertical pipe in RELAP5. When the connection is converted to a crossflow in TRACE, the horizontal pipe is assumed to connect at the cell-center of the target pipe. This will result in a net elevation change of one half the target cells length.

4.2. Radiation Enclosure Beam Lengths

TRACE radiation enclosures define both View Factor arrays and Beam Lengths between heat structure surfaces. Relap radiation components only define the View factors. The R52TRACE plug-in will fill the Beam Lengths array with 0.0 to allow the model to pass TRACE input processing. TRACE accepts a beam length array defined as 0.0, but this input is interpreted to mean the fluid between the surfaces does not participate in the radiation heat transfer.

4.3. Heatstructure General Tables

General tables in RELAP are shared look-up tables that return the appropriate dependent value when provided with an independent value. In this way, a general table that determines heat transfer coefficient based on temperature value may be used by multiple heat structure surfaces, each with a different temperature value.

TRACE general tables require either a control block or signal variable which provide a constant independent variable value source. Each TRACE general table has a single value for a given timestep, based on the value of its independent variable source. A general table which determines heat transfer coefficient based on temperature would provide the same value for HTC for every heat structure surface that uses that general table.

One partial solution is to extract the general table into a Function type control block (ICBN 102) which uses the appropriate surface temperature as the independent variable value.

4.4. Control System Engineering Units

Unlike TRACE, RELAP5 control systems do not include engineering unit specifications for constants, gains, minimum and maximum values. This may result in numerical conversion errors

when converting RELAP5 control systems from a model using British units. The converted model should be carefully reviewed to ensure that the control systems behave properly. Special attention should be focused on Trip setpoints, table entries, and control block initial values.

It is recommended that the RELAP5 model first be converted to SI units in SNAP, and tested prior to converting to TRACE.

4.5. Unsupported Components

The RELAP5 Turbine component, as well as the RELAP5-3D multid and feedwater heater components are not currently supported by the converter plug-in.

4.6. Partially Implemented Converters

The following converters have been partially implemented but require further development.

4.6.1. PipeConverter

The pipe converter must be modified to support the pipe-type flags. These will enable the conversion of CANDU channels, and accumulator components. This converter will must be adjusted to support the final decision regarding bent-pipes as discussed above.

4.6.2. HeatConverter

RELAP5 heat structures contain power data in the source cards. The source data must be converted into spawned power components in TRACE when the source data varies along the length of the heat structure. All the boundary conditions available for RELAP5 heat structures need to be accounted for, and converted correctly to TRACE.

4.6.3. PumpConverter

Further investigation is required to ensure that the PumpConverter correctly converts all types of RELAP5 pumps to TRACE.

4.6.4. ValveConverter

Further analysis is required to ensure that all valid RELAP5 valve types are correctly supported by the conversion utility.

4.6.5. KineticsConverter

The Reactivity feedback data defined inside RELAP5 is not currently converted to the TRACE feedback tables. The process detailing how feedback data should be converted for the different RELAP5 models must be addressed.